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EFFECTS OF ELECTRICAL MUSCLE STIMULATION ON LOWER BACK PAIN

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1. Introduction

Electrical muscle stimulation (EMS) is the elicitation of muscle contraction using electric impulses. EMS has received an increasing amount of attention in the last few years for many reasons. EMS is capable of increasing muscle mass, strength and muscle power. Beyond that, it helps with the conditioning of healthy muscles. Further beneficial effects of EMS are also known, such as helping in weight control or being a solution for conditions such as cellulite. Also, it can be applied as a rehabilitation tool for balancing muscle imbalances caused by inappropriate muscle usage or restructure muscles damaged during aging or injuries.

The electric impulses are generated by EMS devices (XBody EMS devices) and delivered through cables to the electrodes on the skin surface of the muscles to be stimulated. Due to these impulses, the action potential is triggered in a similar way as in the case of impulses coming from the central nervous system. The resulting muscle contraction is similar to the natural movement and regular contractions of the muscles. Depending on the parameters of the electrical impulses (impulse frequency, impulse width, ramp-up, impulse duration, duration of rest), different types of muscle work can be imposed thus improving and facilitating muscle performance of the stimulated muscles.

EMS has several known beneficial effects in clinical applications. It can be used for preventive and rehabilitation purposes in neurology, orthopedics, rheumatology and many other medical fields.

- muscle strengthening, conditioning and increasing muscle mass,
- relaxation of muscle spasm,
- increasing local blood circulation,
- muscle re-education,
- prevention or retardation of disuse atrophy,
- prevention of venous thrombosis of the calf muscles immediately after surgery,
- maintaining or increasing the range of motion.

Lower back pain is one of the most common pain syndromes of the twenty-first century. EMS training can be used to lower pain, and to strengthen weak back muscles, which are one of the most common causes of lower back pain.

Lower back pain is often characterized by pain, muscle tension, or stiffness localized below the costal margin and above the inferior gluteal folds. It can be accompanied with leg pain (sciatica) and is defined as chronic when it persists for 12 weeks or more.

Over 80% of people in developed countries will experience lower back pain at some time in their lives (1) which is the single leading cause of disability worldwide. (2)

Symptoms, pathology, and radiological appearances are various. Pain is non-specific in about 85% of cases. (3)

Men and women are equally affected by lower back pain, which can range in intensity from a dull, constant ache to a sudden, sharp sensation that leaves incapacitates the affected.

The main risk factors include heavy physical work, frequent or repetitive bending, twisting, and lifting; and prolonged static postures. However, the back is a complicated structure of bones, joints ligaments, and muscles and sometimes it only takes a small incident to cause long-lasting lower back pain. In addition, arthritis, poor posture, obesity and psychosocial risk factors such as anxiety, depression, and mental stress at work can all increase the risk of lower back pain as well.

Exercise interventions have been shown in some randomized clinical trials to help prevent lower back pain in at-risk populations. (2) Various published guidelines recommend that patients with lower back pain stay active instead of bed rest as was largely recommended a few decades ago. (3-4) Exercise is recognized to be the only meaningful way to increase functional capacity. (5) Systematic reviews for the management of acute, subacute, and chronic back pain have provided recommendations for more, rather than less, activity in recovery. (6-7)

Not all back pain is the same. Some back pain—identified as a red flag—should not be treated with exercise and requires a much more careful medical workup. Red flag pain may present as unrelenting constant pain that gets worse when the patient lies down, interferes with sleep, and/or accompanies an unanticipated weight loss. Origins of the pain might include a tumor, cauda equina syndrome, infection, or spinal fracture. Although red flag pains require serious consideration, only 1%-4% of patients presenting with back pain have red flag conditions. (8) Patients with red flag pain and those who might present with complicated and/or restrictive comorbidities in addition to back pain are beyond the scope of this education. In case of any medical condition, Patients must first consult with their doctor to ensure proper diagnosis.

Patients with chronic back pain, in general, are less physically active than the majority of the population, meaning most patients with chronic back pain come to therapy with very low physical capacities from a lifestyle that is inhibited by the nature of their pain.

The goal of therapeutic intervention is to return patients to the normal activities of daily living—sitting, rising, bending, twisting, lifting, walking, and climbing—by enhancing strength, flexibility, endurance, and balance.

We hypothesized that an EMS-elicited contraction would be helpful in decreasing the effects of lower back pain.

The aims of this study were:

- Reducing lower back pain through simple training methods re-organizing the subject bad postural positions on different exercises, increasing the range of motion.
- Reducing lower back pain through PNF methods.
- Reducing lower back pain utilizing strength training.

2. Subjects

Four subjects participated in the examination. The subject A (male, 50 years old) suffered from lower back pain caused by lumbar hernia L4-L5. The subject B (male, 49 years old) has lumbar hernia L5-S1. The subject C (male, 48 years old) has cervical Hernia C3-C4. Furthermore, one female subject (subject D, 52 years old) participated in the study with scoliosis.

Exclusion criteria included the contraindications that are described in XBody Client's consent.

3. Procedures

3.1. WB-EMS procedure

Whole body-EMS (WB-EMS) device enables to stimulate the main muscle groups simultaneously. These muscle groups are the trapezius, back, lower back, pectoral, abs, glutes, quadriceps, hamstrings, arms, optional (e.g. shoulders, calves).

Five dynamic exercises for large muscle groups were performed without any additional weights and were structured in 2 sets of 15 repetitions, which lasted 20 minutes.

Exercises	The most loaded regions
Deep Squat	Leg extensor, leg flexor, and gluteal muscles
Glute Bridge	Gluteal, leg flexor, adductor and core muscles
Single Leg Raise	Iliopsoas and abdominal muscles
Overhead Squat	Leg extensor, leg flexor, gluteal and core muscles
T-spine Rotation	Arm, shoulder, core and upper back muscles

Table 1 Load region of the applied exercises

In the first part of the study, an electric current was applied with an impulse frequency of 9 Hz in continuous mode. In continuous mode, the stimulus is generated continuously, without impulse break periods. The pulse width was 400 μs at the subject's maximum tolerance limit, for the first 16 sessions. In the continuous stimulation mode, the inhale-, exhale period were synchronized to the chosen exercises.

In the second part of the study, 16 sessions at 80 Hz were applied in burst mode. In this mode, active stimulation (impulse length) and break periods (impulse break) follow each other. In this case, both the impulse and the impulse break were set to 3 seconds, and the impulse width was 350 μs. The performance of the exercises was synchronized with the 3 seconds impulse length and 3 seconds impulse break stimulation cycle.

The subjects were carefully instructed by research assistants on how to perform the exercises. Furthermore, the participants were acoustically and visually guided by XBody EMS Training videos that exactly controlled the 3-second exercise–3-second rest rhythm of the resistance protocol.

3.2. WB-EMS combined with PNF technique

After the previously described WB-EMS training protocol Proprioceptive Neuromuscular Facilitation (PNF) method was combined with WB-EMS technology for stretching and improving flexibility. PNF technique uses autogenic and reciprocal inhibition and it helps the patient gaining an increased range of motion (ROM). From the starting position a 10 seconds long impulse was applied for a sub-maximal isometric contraction of the target muscle. After it, in the resting period (2 seconds impulse break) active stretch was used to achieve an increased ROM. The subjects were carefully instructed and helped with manual resistance by research assistants to perform the following exercises. The performance of the exercises was synchronized with the 10 seconds impulse length and 2-seconds impulse break stimulation cycle at 9 Hz. The following exercises were performed in the final 4 minutes of the training:

- Glutes stretch in laying position
- Hamstring stretch in laying position
- Abductor stretch in laying position
- Pectoral stretch in sitting/ standing position
- Latissimus dorsi stretch in sitting/ standing position.

4. Measurements

4.1. Anthropometry measurements

Anthropometry measurements were applied. We measured height, weight, and body composition. The body composition was determined by multifrequency, whole-body bioelectrical impedance technique (TANITA - OMRON BF511).

4.2. Pain test

The most important aspect of this test is to identify the severity of the pain. This is a subjective evaluation, which is widely used in clinical practice. The intended use of the pain test is to evaluate the quality of movement patterns for clients during five fundamental exercises according to the following table. Three pain measurements were performed on both sides of the lower back previously the training program, after 16 sessions on 9 Hz and after 16 sessions on 80 Hz.

In this study, six categories of the pain severity were performed according to the followings:

Assessment of pain:

- **0** – No pain
- **1** – Weak pain
- **2** – Mild pain
- **3** – Moderate pain
- **4** – Intense pain
- **5** – Unbearable pain

Subject				
Exercise	**Side**	**No XBody**	**16 sessions 9 Hz**	**16 sessions 80 Hz**
Squat	Left Side			
	Right Side			
Lunge	Left Side			
	Right Side			
Overhead Squat	Left Side			
	Right Side			
Push up	Left Side			
	Right Side			
Rotation	Left Side			
	Right Side			

Table 2 Sample of pain score measurements

5. Results

5.1. Results of subject A

In the case of subject A, an average pain was described before the WB-EMS training program. After the 32 sessions of WB-EMS training program, the pain score decreased to a weak pain with pain score 1. The anthropometric measurements showed notably but not significant changes also. Furthermore, a decrease was observed in body weight, in BMI (body mass index) and in % Fat (percentage of body fat). Besides this, the % Muscle Mass (percentage of muscle mass) increased from 28.1 % to 33.2 % after the 32 sessions of WB-EMS training program. The results are summarized in the following tables.

Subject A – 185 cm						
Baseline data						
Before the first session				Anthropometric Measures (cm)		
				Arms R/L	33	33
				Quadriceps R/L	58	58
Weigh (kg)t	BMI	%Fat	%Muscle Mass	Chest	109	
95.8	28	35.4	28.1	Waist	104	
				Glutes	106	
1st period: Impulse frequency: 9 Hz, Continuous mode, Pulse width: 400 µs						
16 sessions				Anthropometric Measures (cm)		
				Arms R/L	34	34
				Quadriceps R/L	59	59
Weight (kg)	BMI	%Fat	%Muscle Mass	Chest	105	
93.0	27	33.3	30.1	Waist	102	
				Glutes	103	
2nd period: Impulse frequency: 80 Hz, Burst mode, Pulse width 350 µs						
16 sessions				Anthropometric Measures (cm)		
				Arms R/L	32	32
				Quadriceps R/L	57	57
Weight (kg)	BMI	%Fat	%Muscle Mass	Chest	103	
90.2	26	30.1	33.2	Waist	99	
				Glutes	101	

Table 3 Results of subject A

Subject A				
Exercise	**Side**	**No Xbody**	**16 sessions 9 Hz**	**16 sessions 80 Hz**
Squat	Left Side	**3**	**3**	**1**
	Right Side	**3**	**2**	**1**
Lunge	Left Side	**3**	**2**	**1**
	Right Side	**2**	**2**	**1**
Overhead Squat	Left Side	**3**	**2**	**1**
	Right Side	**2**	**2**	**1**
Push up	Left Side	**3**	**2**	**1**
	Right Side	**3**	**2**	**1**
Rotation	Left Side	**3**	**2**	**1**
	Right Side	**2**	**2**	**1**

Table 4 Pain scores of subject A

5.2. Results of subject B

In case of subject B, intense pain (pain score 4) was described before the WB-EMS training program, and it decreased to a weak or a mild pain (pain score 1 or 2) after the 32 sessions. The anthropometric measurements showed changes also, such as notable change was described in case of the chest (from 101 cm to 95 cm), waist (from 98 to 90 cm), and glutes (101 cm to 95 cm) circumference. A decrease in body weight was also observed (from 85.4 kg to 81.9 kg). Furthermore, the BMI (body mass index) and in % Fat (percentage of body fat) decreased. Besides this, the %Muscle Mass (percentage of muscle mass) increased from 29.5 % to 34.6 % after the 32 sessions. The results are summarized in the following tables.

<table>
<tr><th colspan="7">Subject B – 178 cm</th></tr>
<tr><th colspan="7">Baseline data</th></tr>
<tr><td colspan="4" rowspan="3">Before the first session</td><td colspan="3">Anthropometric Measures (cm)</td></tr>
<tr><td>Arms R/L</td><td>30</td><td>29</td></tr>
<tr><td>Quadriceps R/L</td><td>59</td><td>58</td></tr>
<tr><td>Weight (kg)</td><td>BMI</td><td>%Fat</td><td>%Muscle Mass</td><td>Chest</td><td colspan="2">101</td></tr>
<tr><td rowspan="2">85.4</td><td rowspan="2">27</td><td rowspan="2">26.7</td><td rowspan="2">29.5</td><td>Waist</td><td colspan="2">98</td></tr>
<tr><td>Glutes</td><td colspan="2">101</td></tr>
<tr><th colspan="7">1st period: Impulse frequency: 9 Hz, Continuous mode, Pulse width: 400 µs</th></tr>
<tr><td colspan="4" rowspan="3">16 sessions</td><td colspan="3">Anthropometric Measures (cm)</td></tr>
<tr><td>Arms R/L</td><td>31</td><td>30</td></tr>
<tr><td>Quadriceps R/L</td><td>60</td><td>59</td></tr>
<tr><td>Weight (kg)</td><td>BMI</td><td>%Fat</td><td>%Muscle Mass</td><td>Chest</td><td colspan="2">100</td></tr>
<tr><td rowspan="2">83.6</td><td rowspan="2">26</td><td rowspan="2">23.7</td><td rowspan="2">32.4</td><td>Waist</td><td colspan="2">96</td></tr>
<tr><td>Glutes</td><td colspan="2">100</td></tr>
<tr><th colspan="7">2nd period: Impulse frequency: 80 Hz, Burst mode, Pulse width 350 µs</th></tr>
<tr><td colspan="4" rowspan="3">16 sessions</td><td colspan="3">Anthropometric Measures (cm)</td></tr>
<tr><td>Arms R/L</td><td>32</td><td>32</td></tr>
<tr><td>Quadriceps R/L</td><td>57</td><td>57</td></tr>
<tr><td>Weight (kg)</td><td>BMI</td><td>%Fat</td><td>%Muscle Mass</td><td>Chest</td><td colspan="2">95</td></tr>
<tr><td rowspan="2">81.9</td><td rowspan="2">26</td><td rowspan="2">21.5</td><td rowspan="2">34.6</td><td>Waist</td><td colspan="2">90</td></tr>
<tr><td>Glutes</td><td colspan="2">95</td></tr>
</table>

Table 5 Results of subject B

Subject B				
Exercise	**Side**	**No Xbody**	**16 sessions 9hz**	**16 sessions 80Hz**
Squat	Left Side	**4**	**3**	**1**
	Right Side	**4**	**3**	**1**
Lunge	Left Side	**4**	**3**	**2**
	Right Side	**4**	**3**	**2**
Overhead Squat	Left Side	**4**	**3**	**2**
	Right Side	**4**	**3**	**2**
Push up	Left Side	**4**	**2**	**1**
	Right Side	**4**	**2**	**1**
Rotation	Left Side	**4**	**2**	**1**
	Right Side	**4**	**2**	**1**

Table 6 Pain scores of subject B

5.3. Results of subject C

In the case of Subject C, the pain scores decreased from a weak pain (pain score 2) to 0 (no pain) after the 32 sessions WB-EMS training program. The anthropometric measures showed a decrease also. The arm circumference decreased from 33 cm to 31 cm. The quadriceps circumference decreased from 63 cm to 55 cm. The chest circumference decreased from 120 cm to 104 cm after the WB-EMS training program. The circumference of the waist (from 112 cm to 95 cm) and the glutes (from 108 cm to 103 cm) showed a notable decrease also. A decrease in body weight was also observed (from 112 kg to 104 kg). Furthermore, the BMI (body mass index) and in % Fat (percentage of body fat) decreased. Besides this, the % Muscle Mass (percentage of muscle mass) increased from 27.5 % to 32.7 % after the 32 sessions. The results are summarized in the following tables.

<table>
<tr><th colspan="7">Subject C – 180 cm</th></tr>
<tr><th colspan="7">Baseline data</th></tr>
<tr><td colspan="4" rowspan="3">Before the first session</td><td colspan="3">Anthropometric Measures (cm)</td></tr>
<tr><td>Arms R/L</td><td>33</td><td>33</td></tr>
<tr><td>Quadriceps R/L</td><td>63</td><td>63</td></tr>
<tr><td>Weight (kg)</td><td>BMI</td><td>%Fat</td><td>%Muscle Mass</td><td>Chest</td><td colspan="2">120</td></tr>
<tr><td rowspan="2">112</td><td rowspan="2">35</td><td rowspan="2">40.2</td><td rowspan="2">27.5</td><td>Waist</td><td colspan="2">112</td></tr>
<tr><td>Glutes</td><td colspan="2">108</td></tr>
<tr><td colspan="4" rowspan="3">16 sessions</td><td colspan="3">Anthropometric Measures (cm)</td></tr>
<tr><td>Arms R/L</td><td>31</td><td>31</td></tr>
<tr><td>Quadriceps R/L</td><td>54</td><td>55</td></tr>
<tr><td>Weight (kg)</td><td>BMI</td><td>%Fat</td><td>%Muscle Mass</td><td>Chest</td><td colspan="2">106</td></tr>
<tr><td rowspan="2">108</td><td rowspan="2">34</td><td rowspan="2">38.2</td><td rowspan="2">29.5</td><td>Waist</td><td colspan="2">98</td></tr>
<tr><td>Glutes</td><td colspan="2">104</td></tr>
<tr><th colspan="7">2nd period: Impulse frequency: 80 Hz, Burst mode, Pulse width 350 µs</th></tr>
<tr><td colspan="4" rowspan="3">16 sessions</td><td colspan="3">Anthropometric Measures (cm)</td></tr>
<tr><td>Arms R/L</td><td>31</td><td>31</td></tr>
<tr><td>Quadriceps R/L</td><td>55</td><td>55</td></tr>
<tr><td>Weight (kg)</td><td>BMI</td><td>%Fat</td><td>%Muscle Mass</td><td>Chest</td><td colspan="2">104</td></tr>
<tr><td rowspan="2">104</td><td rowspan="2">32</td><td rowspan="2">35.0</td><td rowspan="2">32.7</td><td>Waist</td><td colspan="2">95</td></tr>
<tr><td>Glutes</td><td colspan="2">103</td></tr>
</table>

Table 7 Results of subject C

Subject C				
Exercise	**Side**	**No Xbody**	**16 sessions 9hz**	**16 sessions 80Hz**
Squat	Left Side	**2**	**1**	**0**
	Right Side	**2**	**1**	**0**
Lunge	Left Side	**2**	**1**	**0**
	Right Side	**2**	**1**	**0**
Overhead Squat	Left Side	**2**	**1**	**0**
	Right Side	**2**	**1**	**0**
Push up	Left Side	**2**	**1**	**0**
	Right Side	**2**	**1**	**0**
Rotation	Left Side	**2**	**1**	**0**
	Right Side	**2**	**1**	**0**

Table 8 Pain scores of subject C

5.4. Results of subject D

In the case of subject D, the pain score decreased to 0 (no pain) or 1 (weak pain) after the 32 sessions of WB-EMS training program. The anthropometric measures showed a decrease also. The arm circumferences decreased from 30 cm (right) and 29 cm (left) to 26 cm. The quadriceps circumferences decrease from 58 cm (right) and 59 cm (left) to 53 cm. The chest circumference decreased from 88 cm to 80 cm during the WB-EMS training. The circumference of waist (from 95 cm to 82 cm) and glutes (from 103 cm to 95 cm) showed a decrease also. The body weight decreased from 74.5 kg to 68.7 kg. Furthermore, the BMI (body mass index) and in % Fat (percentage of body fat) decreased. Besides this, the % Muscle Mass (percentage of muscle mass) increased from 23.9 % to 28.1 % after the 32 sessions. The results are summarized in the following tables.

<table>
<tr><th colspan="7">Subject D – 170cm</th></tr>
<tr><th colspan="7">Baseline data</th></tr>
<tr><td colspan="4" rowspan="3">Before the first session</td><td colspan="3">Anthropometric Measures (cm)</td></tr>
<tr><td>Arms R/L</td><td>30</td><td>29</td></tr>
<tr><td>Quadriceps R/L</td><td>58</td><td>59</td></tr>
<tr><td>Weight (kg)</td><td>BMI</td><td>%Fat</td><td>%Muscle Mass</td><td>Chest</td><td colspan="2">88</td></tr>
<tr><td rowspan="2">74.5</td><td rowspan="2">26</td><td rowspan="2">39</td><td rowspan="2">23.9</td><td>Waist</td><td colspan="2">95</td></tr>
<tr><td>Glutes</td><td colspan="2">103</td></tr>
<tr><th colspan="7">1st period: Impulse frequency: 9 Hz, Continuous mode, Pulse width: 400 µs</th></tr>
<tr><td colspan="4" rowspan="3">16 sessions</td><td colspan="3">Anthropometric Measures (cm)</td></tr>
<tr><td>Arms R/L</td><td>28</td><td>28</td></tr>
<tr><td>Quadriceps R/L</td><td>56</td><td>56</td></tr>
<tr><td>Weight (kg)</td><td>BMI</td><td>%Fat</td><td>%Muscle Mass</td><td>Chest</td><td colspan="2">83</td></tr>
<tr><td rowspan="2">71.8</td><td rowspan="2">25</td><td rowspan="2">36.9</td><td rowspan="2">26.0</td><td>Waist</td><td colspan="2">87</td></tr>
<tr><td>Glutes</td><td colspan="2">98</td></tr>
<tr><th colspan="7">2nd period: Impulse frequency: 80 Hz, Burst mode, Pulse width 350 µs</th></tr>
<tr><td colspan="4" rowspan="3">16 sessions</td><td colspan="3">Anthropometric Measures (cm)</td></tr>
<tr><td>Arms R/L</td><td>26</td><td>26</td></tr>
<tr><td>Quadriceps R/L</td><td>53</td><td>53</td></tr>
<tr><td>Weight (kg)</td><td>BMI</td><td>%Fat</td><td>%Muscle Mass</td><td>Chest</td><td colspan="2">80</td></tr>
<tr><td rowspan="2">68.7</td><td rowspan="2">24</td><td rowspan="2">34.8</td><td rowspan="2">28.1</td><td>Waist</td><td colspan="2">82</td></tr>
<tr><td>Glutes</td><td colspan="2">95</td></tr>
</table>

Table 9 Results of subject D

Subject D				
Exercise	**Side**	**No Xbody**	**16 sessions 9hz**	**16 sessions 80Hz**
Squat	Left Side	**3**	**2**	**0**
	Right Side	**3**	**1**	**0**
Lunge	Left Side	**3**	**2**	**1**
	Right Side	**3**	**1**	**1**
Overhead Squat	Left Side	**4**	**2**	**1**
	Right Side	**4**	**2**	**1**
Push up	Left Side	**3**	**2**	**0**
	Right Side	**3**	**1**	**0**
Rotation	Left Side	**2**	**2**	**0**
	Right Side	**2**	**1**	**0**

Table 10 Pain scores of subject D

6. Discussion and conclusion

The lumbar spine, or low back, is a remarkably well-engineered structure of interconnecting bones, joints, nerves, ligaments, and muscles. All working together to provide support, strength, and flexibility. The purpose of this study was to determine the effect of WB-EMS training method with XBody EMS device on lower back pain.

From the four described cases, it can be concluded that WB-EMS can be a great help to people with lower back pain. The measurement showed a reduction in weight with positive body composition changes, namely the % Fat decreased, and the % Muscle Mass increased in case of every subject. A decrease was observed in the case of anthropometric measurements also. In addition, pain test was applied to identify the severity of the lower back pain of the subjects. In all cases, pain test showed positive effect of WB-EMS training program on lower back pain by minimizing or eliminating their symptoms.

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